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THE DEVELOPMENT OF COMPUTER MODEL OF CONTINUOUS DIGGING MACHINE EASI-MINER AT OBED MOUNTAIN MINE

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October 1986

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THE DEVELOPMENT OF COMPUTER MODEL OF CONTINUOUS DIGGING MACHINE "EASI-MINER" AT OBED MOUNTAIN MINE

Proposal for field data collection and evaluation.

by

V.Srajer*, G.Acott**

ABSTRACT

In this report, a preliminary proposal for field data collection and evaluation of the "Easi-Miner" operation at Obed Mountain mine is presented. This proposal was used to establish objectives for field work at the mine and to inform all parties involved about the intention and reason behind the field work.

The "Easi-Miner" application at the Obed Mountain mine is explained and an overview of the mining operation is presented. This report also includes the initial specifications of the proposed computer model.

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MISE AU POINT D'UN MODÈLE INFORMATISÉ D'UNE EXCAVATRICE EN CONTINU "EASI-MINER" À LA MINE OBED MOUNTAIN

Proposition d'une cueillette et évaluation de données sur le terrain

par

V. Srajer* et G. Acott**

RÉSUMÉ

Le présent rapport a pour objet la présentation d'une proposition préliminaire pour effectuer la cueillette et l'évaluation des données in situ sur le fonctionnement de la machine "Easi-Miner" à la mine Obed Mountain. On s'est servi de cette proposition afin d'établir les objectifs des travaux sur le terrain à la mine et de renseigner toutes les parties en cause sur les intentions et motifs derrière cette recherche.

De plus, l'utilisation du "Easi-Miner" à la mine Obed Mountain est expliquée et un aperçu des opérations minières est présenté dans ce rapport. Enfin, il comprend aussi les spécifications établies à l'origine du modèle informatisé proposé.

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INTRODUCTION

The CANMET,Surface Mining Laboratory of Devon, Alberta and Obed Mountain Coal Company of Hinton, Alberta, agreed in principle to jointly develop a computer based operational model of the "Easi-Miner", continuous coal excavation machine introduced at the Obed Mountain Mine.

It is expected that the computer model, when developed, will serve as a basic monitoring and event-based modelling tool of the continuous mining operation system, presently used at the mine. The model will also be incorporated into the hierarchy of other models presently under development at CANMET and the National Research Council of Canada. It is expected the model will be included in the recently introduced TRUCK/SHOVEL model as a loading alternative. In addition, the newly developed "Easi-Miner" module is expected to be used independently as a mine operation monitoring tool, addressing short term planning needs and to help solve day to day problems at the mine.

The computer based model of "Easi-Miner", even if developed for specific mine applications, will be general in its structure so that it can be used for similar applications elsewhere.

In this report a proposal for field work, to collect operational data and to understand "Easi-Miner" application, is presented. The requirements for the model and specifications of the model as seen by the future user, are presented for discussion. A plan for field data collection and evaluation was prepared by CANMET, model requirements and its specifications were written by Obed Mountain Mining Co.

OBED MOUNTAIN MINE

Mining Operation

The Obed Mountain Coal Company mine is located approximately 24 km northeast of the town of Hinton in vest-central Alberta. It is an open pit mine projected to produce 3 Mt/year of bituminous, high volatile thermal coal (1). The mine, built and operated by Union Oil Company of Canada Ltd, is uses state of the art mining and processing technology (2).

The mine is located in Alberta's Foothills. The two principal coal seams, suitable for surface mining, are of lover tertiary age, in the Paskapoo formation. These seams are virtually horizontal and range in thickness from 3.9 to 4.5 m (1). The reserves in the Obed March formation has been estimated at 188 Mt of coal in mineable seams, with 147 Mt of recoverable coal. It is estimated that 91 Mt of clean coal, having heating value of 2 800 PJ, may be ultimately recovered from the mine (3).

The overburden is removed by a Page-757 dragline with a 57.4 m^3 bucket and a 88.7 m boom inclined at 33 degrees from the horizontal. Two P&H-2100 BL cable shovels with 13.7 m^3 buckets, Letourneau L-800 and Caterpillar-988 front end loaders, and 12 Wabco-120C rear dump haulers are other major equipment used at the mine for waste removal and coaling operations (4). The continuous mining machine, the "Easi-Miner" is used exclusively for loading coal from the exposed seam into haulage trucks.

The mined coal has a density of 1 530 kg/m^3, and a svell factor of 1.35. The coal moisture is estimated at 18 percent.

Additional pit parameters are listed as follovs (4) :

- coal production 4.6 Mt of rav coal annualy,
- plant yield of 65 %,

- pit length up to 2 000 m,
- pit width of 50 m,
- highwall angle of 55 degrees,
- spoil angle of 34 degrees,
- angle of coal of 85 degrees,
- average overburden thickness of 20 m,
- no.2 seam mining thickness of 2.75 m,
- interburden thickness of 12.5 m,
- no.1 seam mining thickness of 3.00 m,and
- mine haulage road width of 30 m.

The coaling operation is scheduled to be 175 days/year. Production is from 2 shift/day of 11 hours/shift operation. The loading and hauling operation is scheduled at 3850 hours annualy. The production rate is therefore in excess of 1 800 t/hr on a 2 shift basis. The coal is mined by the "Easi-Miner" and transported by 109 t rear dump Wabco 120C trucks into the coal preparation plant. Support equipment, such as dozers, are used for ramps into the seams Nos.1 and 2, scrapers are used for steps removal at the highwall and spoil.

Production commenced from the Obed North block, and later is planned to be moved to the South block. Preproduction waste removal was handled by an outside contractor (North American Road and Construction Ltd.) and involved moving over 1.5 Mm^3 by scrapers, trucks and backhoes. The mine haulage roads were constructed using overburden rock and gravel from within the initial mining areas. This activity exposed some 600 000 t of coal for plant start up and stockpiling.

The coal at the mine site is stored in a 45 000 t capacity "Glory hole" - reinforced earth-wall structure, the largest in the world. The "Reinforced Earth" (trademark name) is made of granular compacted backfill material-reinforced with steel strips and faced with the concrete panels,which are the only portion of the wall visible after the construction is completed.

Easi-Miner Application

One of the prime reasons for using the Easi-Miner for Obed Mountain coaling operations was its effect upon the wash plant. The question was, would the plant operate more effectively with full face material, or would selective mining increase the recovery and increase the plant efficiency. The coal seam could be cut on a slight gradient, thereby producing a full face product, or the coal may be stockpiled and reclaimed later by front end loaders, and blended if required. Coal dilution was a major concern for full face mining since the coal preparation plant might not be able to process diluted coal. The foremost requirement for the cutting machine was therefore its ability to control the coal horizon, particularly if any irregularity exists in the seam. An established standard practice is to use the first cut as a guide. The operator may observe the previous cut when cutting the second or any following cuts and visually judge how well he negotiated the floor. In the upper seam sandstone lenses are encountered. The machine comes under stress and there is a noticeable vibration throughout the machine. The operator must than slow the machine down and raise the cutting head.

Several continuous surface miners were investigated before purchase. These included:

-Easi-Miner from Huron Manufacturing Co.,
-Surface Miner from Wirtgen,
-WL-50 from McNally Pittsburg,
-Continuous Excavator from Forster Miller,
-Rotaminer from Babcock Construction,
-TR and PR Series from CMI,
-Unimatic from Unit Rig and Equipment Co.,and
-INC-SC-3 000 from Satterwhite International.

The selection then concentrated on Huron's Easi-Miner and Wirtgen's Surface Miner, because it was felt that this type machine best suits the

mine requirements. Both machines are technicaly compatible, except the Wirtgen's cutting drum revolves counter clockwise in the direction of machine travel while the Easi-Miner's cutting head rotates in the opposite direction. It was felt that the Wirtgen machine could present a problem in handling material, so the Easi-Miner was selected. Two models of the Easi-Miner were then investigated: type 1018 and 1224. The type 1224 fitted the projected production output of ROM coal of 1 000 t/hr and was therefore selected.

The specification of the selected machine is as follows:

Model	Easi Miner 1224
Operating weight	110 t
Dimensions	4.9 m x 28.0 m
Designed production	2 000 t/hr
Cutting head	
-diameter	224 cm
-width	414 cm
-depth	0-61 cm
Conveyors	
-length of main	823 cm
-discharge	1525 cm
-height of discharge	793 cm
-width	183 cm
-discharge swing	0-210 degree
Propel speed	0-1.02 m/sec
Power source	Cummins KTA 2300
Power required	900 KW

A sketch of the Easi-Miner operating at the mine, loading Wabco 120 t rear dump trucks is shown on Fig.1 (4).

In summary, the Easi-Miner was selected for the following reasons:

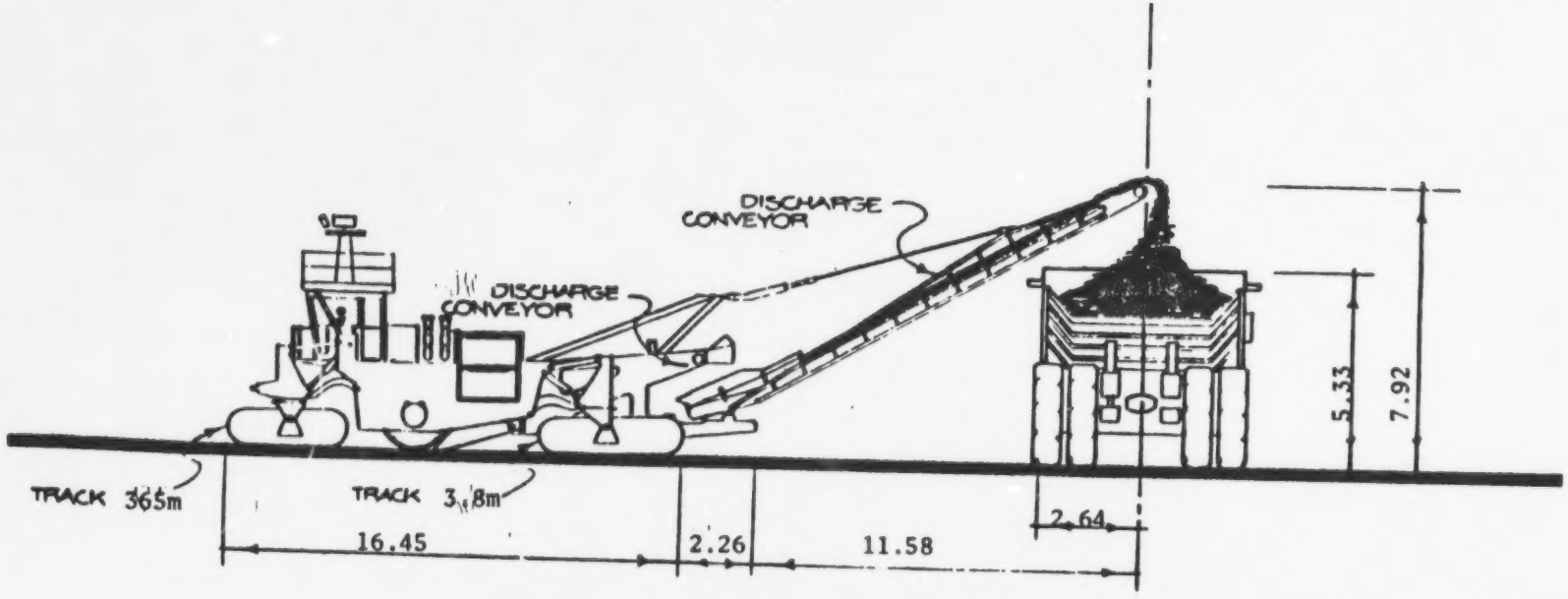

Fig. 1 - "Easi-Miner" Loading Wabco 120D Truck (4)

1.Blasting of the coal was not required.
2.Selective removal of clay and partings in excess of 50 mm thickness is posible.
3.Even size distribution of ROM coal.
4.High production capacity (peak production of 1 800 t/hr).
5.Ideal machine for flat seam mining.
6.Lov operating cost.
7.Capital cost lower then for power shovel.
8.Lov bearing pressure,similar to D8 dozer.
9.Easy cutting of frozen material.
10.Elimination of in-pit road - trucks can drive on top of seam as it is mined down.

COMPUTER MODEL

Specification and requirements

It is proposed that the computer model of "Easi-Miner" be designed as an independent module of the truck and shovel system, using the "Easi-Miner" as a loading unit. Because the loading unit in this case will not be stationery, special procedures will be implemented in the model to account for mobility of the loading and hauling unit during actual loading. The distanmce travelled during loading will be deducted from the hauling time of the last truck. Provision for changes in travel times must be included in calculation of travel times: both hauling and return times will be constantly changing. Alternatively, travel times during the loading operation may be listed separately, for example as they travel in the pit. The queuing times will include the time the vehicle waited for loading, folloving the vehicle being loaded, and stationery time, when the vehicle waits for a signal to drive to the "Easi-Miner" and commence loading. Also, some delay times may be included in the queuing time, depending on the requirements of the model by operations personnel. At this stage, these times were not

specified. Provision to implement these changes in the model at a later stage should be included in the model.

The model should accept time study data, data supplied by the manufacturer, or calculated data for the preliminary simulation run. The data from time study or manufacturers data will be provided, and it will be an option for the user to choose between these two or a combination of both data types.

The truck haulage distance will be calculated separately for each cycle, or will be calculated as an average for the whole block to be mined, or for the specified period of time. For example, a four day coaling operation will have a projected truck haulage distance. This projected truck haulage distance may also be used in predicting truck haulage times for longer periods of time, for long term planning, and so on.

The truck cycle time will be another variable event and will be calculated for each truck individually, or for the fleet of trucks.

Other events to be monitored, will include turning time and thickness of "Easi-Miner" cuts, thickness of the seam, number of the seam. Provision for statistical and accounting information must include data listing truck capacities, number of trucks operating in the period of time, fuel and power consumption.

Another important factor requested from the simulation model will be monitoring of the width of the dragline cut. The dragline operation must be ahead of the "Easi-Miner" operation, so both events do not interfere with each other. Monitoring of the dragline cut will also be used to identify the supply of "open coal reserves" for the coaling operation. This may be used for continuous planning purposes, to specify and secure "Easi-Miner" availability, and to provide a "window" to mine maintenance for PM planning for both equipments: dragline and "Easi-Miner".

The computer model should be capable of determining the equipment hours required to mine a specific quantity of coal. This may include both the

"Easi-Miner" hours and the number of the trucks needed to haul this coal. The model must be able to predict the optimum operating procedures for the "Easi-Miner", such as depth of the cut and the minimum efficient cut length. The model must include provisions to monitor the quality of the coal from different cuts and from various shifts.

Separate model of the "Easi-Miner" must provide information for each phase of the operation: cutting, crushing and carrying phases. The parameters monitored during the cutting phase will include the time needed to cut specified quantities of coal, impact speed [in m/s] and impact force [in MN/m] of the tooth points. The model should also specify the inclination of the tooth shears for optimum cutting of the specified material. The crushing phase monitored will include estimation of the optimum size of the material mined, optimum downward pressure of the cutting head and optimum rotation speed of the head. By testing the equipment for various combinations of ground speed and cutting head pressure, the size of crushed material is controlled. If ground speed is increased, the teeth accept a longer reach. By taking a shallow draft at high ground speed the crushing process is minimized. By slowing the travel rate and setting the draft deeper, the crushing activity is increased, producing a more fractured product. The carrying phase monitoring will include time and distance measurements of the fractured material to be moved to the pick-up conveyor. Variation of the speed of the carrying conveyor will produce excessive dust or be one of the reasons for reducing the equipment output.

The production of the "Easi-Miner" may be monitored and be variable depending on material cutted, time of the day, weather, operator efficiency, and so on. It will also be directly related to the availability of other equipment, truck operator efficiency, ground preparation, maintenance service, etc.

The model will also keep track of delay data, productive and non-productive times, maintenance times, etc. The model must be able to select and summarize these data on demand or provide periodic reports.

FIELD WORK PROPOSAL

Site Preparation

Only minimum site preparation will be required for the field study. The Mine Engineering Department of the mine will notify CANMET two weeks in advance about the scheduled coaling operation. It is understood that at present, the first coaling operation acceptable to both parties, that may be monitored is scheduled from November 2 to 5,1986. CANMET's staff will arrive at the mine site the day before to discuss the field study and site preparation with the mine engineer. The mine surveyor will be requested to mark sections of the seam with clearly visible markers, as is, for example, illustrated in Fig.2. The markers are proposed to be placed 25 m apart, outside of the "Easi-Miner" path, so they will be saved through the entire coaling operation. The markers will divide the seam into several sections, named A, B, C, D,...etc. These sections will be perpendicular to the mine face and to the cutting path of the "Easi-Miner". Each section will then be divided into rectangles 1, 2, 3, ...etc. for each pass of the "Easi-Miner". Depth of the cut will be added to each rectangle to create blocks of coal. The dimensions of the block will therefore be the width of the section, width of the cut, and depth of the cut. The quantities of the coal in the block will then be calculated based on the supplied parameters.

Data Collection

The field survey will consist of two people. One worker will note the times when "Easi-Miner" passes each marker and will also note times of "Easi-Miner" delays. The other worker will note times of the truck arriving in the pit, arriving in the queueing line, ready for loading, start of loading, completion of loading, leaving "Easi-Miner", and leaving pit area.

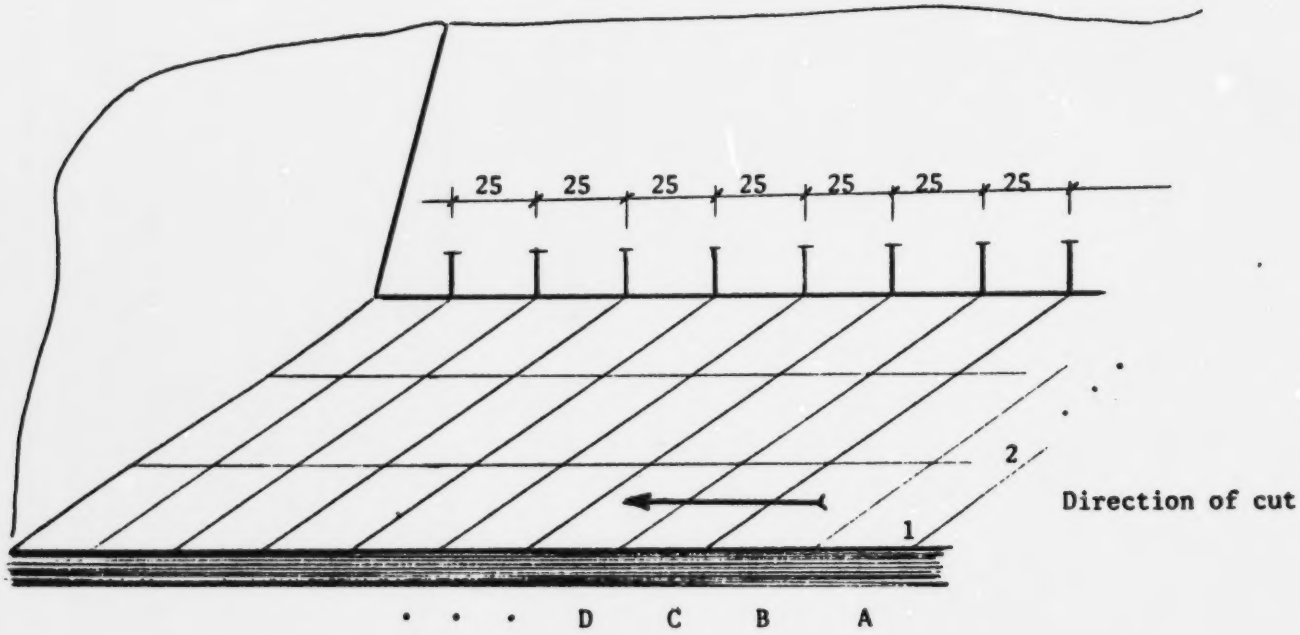

Fig. 2 - Site Preparation

Worker number one will also note down location of the truck at commencement and completion of loading, with relation to the markers.

The proposed field time sheet for worker number one is shown in Table 1, for worker number two in Table 2.

By using this proposed time study approach, the following data will be available after the time study is completed:

1. Quantities hauled in time
2. Truck loading times
3. Truck queuing times
4. Truck movement during loading
5. Truck positions during loading operation
6. Truck delay times
7. Truck loading factors
8. Coal quantities moved in time
9. "Miner" productivities
10. "Miner" digging and travel speed
11. Loading and waiting times
12. Interaction with other equipment that cause delay

By providing information on causes of delays, these delays may be identified and estimates made for lost production because of delays. It is expected, this information from field study will be helpful in identifying the position of truck and "Miner" at various times, the quantities removed and also to provide field data for development and validation of computer based model of the "Easi-Miner" operation.

This field study is proposed to be repeated again during good weather, and repeated again during winter. This approach will give separate sets of data for possible correlation, if differences become noticeable. It may also be possible to take time studies of the coaling operation of Seam No.1 and 2 and compare the differences, if any.

Table 1 - Data Collection Sheet for Easi-Miner

EASI MINER DATA SHEET | Page:

MINE: OBED MOUNTAIN COAL | DATE:

OPERATION | DELAY

MARKER			MARKER			MARKER			TIME		REASON
No.	Time	*	No.	Time	*	No.	Time	*	On	Off	Note

*: L . . . Truck Loading Started
C . . . Truck Loading Finish

Table 2 - Data Collection Sheet for Truck

TRUCK DATA SHEET									Page	
MINE: OBED MOUNTAIN COAL							DATE:			
TRUCK	OPERATION							DELAY		
	Arrive	Queuing	Ready	Load	Compl.	Leave	Exit	Start	Finish	*

*: Reason for Delay

The first time study will be made using the stop-watch approach. During the second study, when monitoring of the equipment will be more routine, a hand-held data gathering device, "Polycorder", will be used. It is expected, that the "Polycorder" will be reprogrammed in the light of information gathered during the first field time study.

Data Evaluation

Data from the first study will be evaluated by CANMET before commencement of the second study. A program for "Polycorder" and for computer evaluation of the data will be written to speed up data evaluation. A separate report on data evaluation will be written for the summer and winter results. The data will be compared and correlated. The final report will include evaluation of field results and will provide specifications for the computer model and list requirements for usage of the model.

The data will be evaluated in a similar fashion to the approach used when draglines at the Highvale Mine were studied (5), providing data on real operating times, evaluation of productive and delay times, evaluation of machine performance and productivity, illustrating equipment's time variability and time histograms of related functions.

The collected data will then be used to understand, develop and validate a computer model of the continuous mining operation. The model will then be used by mining company to help them understand, evaluate and monitor the continuous mining system.

It is expected that the first report on the summer data collection will be available to the mine engineering by the end of December 1986. A second report with program listing of application of Polycorder to collection of field data from Easi-Miner is expected to be presented by the end of January 1987. The report on winter data collection is expected to be completed 3-4 weeks after completion of winter field work, estimated to be by

the end of March 1987. The first version of the computer model of "Easi-Miner" is planned to be presented for review in fall 1987.

CONCLUSION

The development of a computer model of "Easi-Miner" operation as presently practiced at the Obed Mountain mine, has been proposed. This report provides overview of the mining operation and the "Easi-Miner" application at the mine. The specifications of the model as seen during this stage of investigation, are provided.

It is proposed to commence field work at the mine to collect data on the "Easi-Miner" operation, to understand the operation and to solicit definitions and requirements for the model from mine engineering and operation personnel. The time studies proposed and outlined in this report are subject to review after completion of the first round of data collection, depending on circumstances, changes in definition of model requirements, and so on. Several stages and approaches in data collection and evaluation are also proposed in this report.

ACKNOWLEDGEMENT

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